PART II: PROCESSES OF VISUAL PERCEPTION AND THEIR EDUCATIONAL IMPLICATIONS

INTRODUCTION

Visual perception is a very complicated phenomenon and there are many types of visual information that can be detected and interpreted. The various types of information can be roughly grouped into processes according to the kinds of things they enable us to find out about the environment. Color perception involves the ability to perceive differing colors and pigments in the visual field and is basic to any other visual process. The process which enables us to selectively attend to just one specific aspect of the visual field is called figure-ground perception and also underlies all vision. Object or shape perception includes processes that enable us to see objects, shapes and forms. Other processes give us information about the overall layout of the environment and constitute space, distance or depth perception. Finally, movement perception gives us knowledge of motion and events.

It is important to remember that human vision has evolved so that interpretation of three-dimensional visual patterns is the normal experience. Experiments with children show that three-dimensional form discriminations are much easier to learn than two-dimensional ones (Pick & Pick, 1970), indicating that the human visual system is equipped to deal primarily with three-dimensionality. With the evolution of human culture, two-dimensional visual arrays have become increasingly important as representations of objects and as notational systems for language, math, music, etc. The processes involved in two dimensional perception are the same as in three-dimensional, but certain aspects assume greater importance. For example, line perspective becomes very important in two-dimensional representations of depth whereas motion parallax cannot be used at all. As mentioned before, there are generally fewer cues available in two-dimensional patterns so that ambiguities are possible and learning is therefore more complicated. But perception of two-dimensional stimuli is especially important in schools where children will wish to read, paint, draw, read maps and make diagrams. For this reason, each process will be discussed in terms of the three-dimensional cues that are available and the special considerations that arise when the visual array is limited to two dimensions.

Although the processes of vision are dicussed separately, it must be remembered that they all operate simultaneously and that some of the processes are involved in every other process. For example, it is a moot point whether depth would exist visually if there were no objects. When we look straight up at a cloudless sky, there is no real sense of depth, there is merely a sense of no objects. It is only when a bird flies across the visual field that we can have any sense of the distance involved. By the same token, figure-ground perception is always involved in object perception. In fact, figure-ground becomes meaningless if there is no object or shape to conceive. But there are some unique aspects of visual learning that are clearly exposed only when the possible kinds of differentiations and integrations are discussed separately. Understanding the processes individually can also give a teacher some powerful diagnostic and prescriptive tools.

Since this paper is a general introduction to visual perception, only a brief description of each process will be given. They are all subjects of separate specifications. The intent of this paper is to describe the main types of information that can be detected and interpreted. Implications for education will also be mentoined that suggest ways in which teachers might arrange environments and guide interactions to maximize competence in visual perception.

COLOR PERCEPTION

The word color has been used with many different meanings and it is difficult to choose just one meaning. In one sense, any contrast in the environment is a contrast of color, regardless of the origin of that contrast. The least confusion probably results from defining color to mean the pigmentation of substances in the environment (as suggested by J. Gibson, 1966). Then color perception can be defined as the ability to differentiate, integrate and generalize visual cues that indicate the differing pigmentations of substances. This includes both pigments that are selective for certain wavelengths and reflect specific hues (such as red, green, blue, etc.), and unselective pigments that yield the various shades of white, grey and black. This agrees with the common usage of the term color to indicate white and black as colors.

The ability to see color probably evolved through the need to detect differences among substances that only pigmentation could reveal. For example, it has been suggested that vertebrate color perception is most clearly developed among fruit-eating animals that needed to detect color differences between ripe and unripe berries. In man, color perception is highly refined and it has been estimated that the human eye can discriminate upwards of ten million different colors (Evans, 1974). Traditionally, it has been maintained that there are primarily three variables in the perception of color: hue, saturation and brightness. Recent research, however (Evans, 1974), has indicated that the adaptation of the eye to the surroundings plays a crucial role in determining what color will be seen and that at least two other variables are necessary to fully explain the appearance of a color. These complexities in the nature of color perception partially explain why research on the development of color perception is so inconclusive.

It is known that infants prefer bright objects to dim ones, but it has been very difficult to determine ages at which infants can attend to color as an independent aspect of an object. Even kindergarten children will sometimes have difficulty naming the colors of objects placed before them.

Man has exploited his perceptual abilities to the utmost and color perception plays a very important role in the modern world. Color conveys meaning in traffic lights, highway signs, brakelights and police lights. Filing systems, exit patterns and even units in textbooks are all color coded. Subtle color differences can tell us that the experiment has suceeded or that the meat has gone bad. And not least important, color is used for aesthetic purposes in paintings and graphic art as well as in schools, homes, offices, bus terminals and even gas stations.

For all practical classsroom purposes color experiences can investigate the three basic aspects of hue, saturation and brightness. Hue is most closely associated with wavelength and refers to the perceived wavelength, e.g., red, blue, or green. Saturation refers to the amount of a certain hue present. For example, white paint can be added to red paint to produce colors that are increasingly less saturated. Finally, the concept of brightness can be simplified to mean the intensity of colors that have a certain hue and saturation. For example, pink (a red hue of low saturation) can vary from bright pink to greyish or blackish pink.

Since color is an aspect of virtually every visual perception, it can be part of any visual learning experience. By focussing on specific color characteristics a teacher can help a child develop an ability to perceive increasingly subtle differences in shade. Ordering colors according to intensity, mixing new color combinations and matching shades of color can all be important and enjoyable learning experiences. Children can use prisms to find the colors in sunlight and learn about what happens when colored lights are mixed and when colored pigments are mixed. Paintings and designs can be made from several shades of just one hue (for example, five shades of red) or two hues canbe used to determine the possible colors that can be obtained. Interesting observations can be made concerning patterns of light and dark by comparing black and white photos of objects to the real thing. And natural camouflage can be studied to determine just how it is that an animal blends in with its background. Finally, the aesthetic aspect of coloring can never be overlooked. It is a prime source of pleasure and happiness, and children who are raised to be sensitive to qualities of color differences will be much more likely to insist on having asethetic environments when they become adults.

FIGURE-GROUND PERCEPTION

In some ways, figure-ground perception is the most basic process in any perceptual act since it involves the ability to selectively attend to one particular arrangement of stimuli over all other possible arrangements. It is defined as the ability to differentiate features within a visual field and integrate them into a pattern that becomes the main visual focus. The remainder of the field becomes background or simply ground (see Fig. 10).

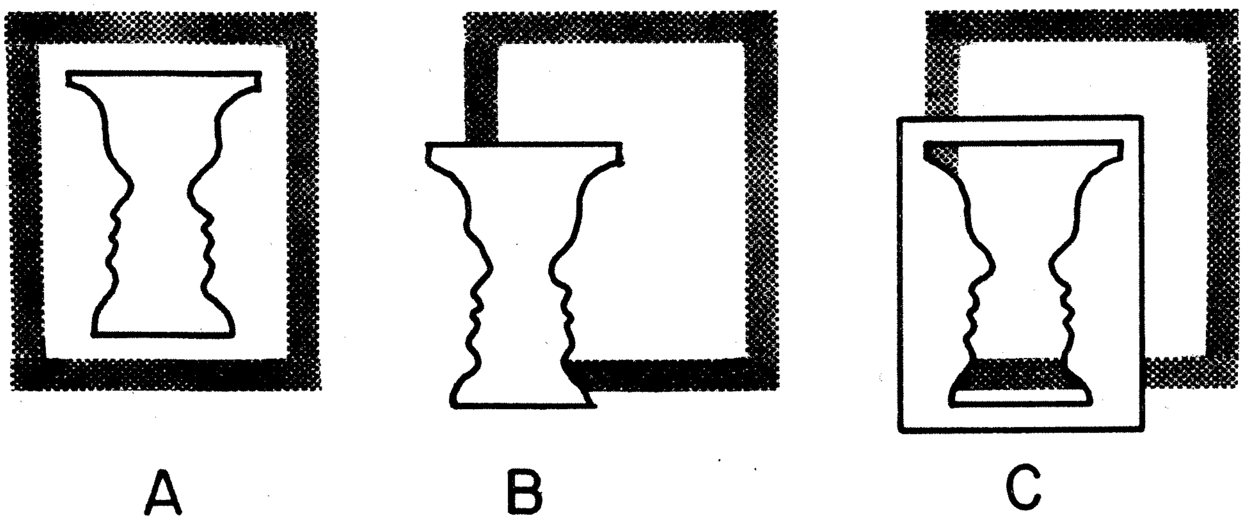

Figure 10.

Figure-ground perception. In (A) either the vase (B) or the two faces (C) can be seen as the figure. But both cannot be seen at once. (After Hochberg, 1964.)

The significance of figure-ground perception in nature is amply attested by the many examples of protective coloration and camouflaging in animals. The form of this protection is to make the figure appear as much like the background as possible. Almost everyone is familiar with moths that match tree bark, insects that look like sticks and chameleons that even change their color to match the background. Other striking examples are the zebra and giraffe whose coats indicate that animals preying on them are not sensitive to color since the camouflaging only matches the background with areas of light and dark.

For early man there was obviously survival value in being able to detect a bird in the bush, but the importance of figure-ground perception is even more basic than this. Whenever any type of looking or manipulation occurs, it is necessary to attend to a specific object or aspect of the visual field and let other objects competing for attention drop into temporary insignificance. However, if anything should suddenly occur within the background, it could assume primary focus and become the new figure.

In a three-dimensional situation, the figure is only obscured if the colors of the object blend into the background. Depth cues will always tell if the object is distinct. But in two-dimensional patterns, depth cues can often be absent and two figures can even share the same border (see Fig. 10). It was this situation that highlighted the significance of figure-ground processes since it was pointed out that only one figure at a time could be seen. When depth cues are added to the figure, the ambiguity disappears and the figure is made clear. However, the ambiguity of the plain line drawing emphasizes the impossibility of seeing two figures at once. It can be seen as one or the other, but not both simultaneously.

It has been clearly demonstrated that even neonates have some ability to differentiate figures (Fantz, 1963, among others). Certain kinds of figures are preferred over others and the fact that an optimal degree of complexity is preferred indicates that fairly significant differentiations can be made. As the infant matures, his increasing visual experiences makes possible the perception of more complex figures and patterns. These patterns can eventually be recognized even when surrounded by a wealth of other irrelevant patterns. As competence is developed, the human being becomes more capable of very subtle perceptions like seeing faint tubercular patterns in a chest X-Ray. This is an example of figure-ground perception that calls for much training and experience.

The development of figure-ground perception has many important implications for education. First, it indicates that for very young children, a figure is most easily seen by itself on a clearly contrasting background. The practice in many beginning reading textbooks of having snakes slithering all over the letter "S" is a clear violation of this principle because it obscurs the truly distinguishing features on an "S". Applying the principle of clarity will also affect the arrangement of the environment. For example, if we want a child to see a painting, then we must clear a large space on a plain wall, hang the picture at the proper level, and make sure it is well lighted. (Japanese flower arranging utilizes this principle to the utmost. Only one or two perfect blossoms are chosen and set off from all the others.) If competence is to be increased, children should be exposed to many types of figures and patterns so that they will be sensitive to many types of visual forms. Also the child knows how to go about searching for patterns and trying out possible integrations will have a greater chance of accurately perceiving new patterns.

There are a number of familiar perceptual tasks that involve figure-ground perception such as mazes, connecting dots, and embedded figure drawings. However, almost any visual experience can help to develop figure-ground perception if the teacher is aware of the processes involved. For example, children can look around the room to find "hidden shapes", objects that have forms of squares, circles, etc. Children can find patterns in the veins of leaves and then match their patterns with those of other children. They can see what shapes make up a car or how many circles they can find on a car. In science they can learn about protective coloration and study pictures of camouflaged animals. They can even go on a nature walk to find moths or insects that are "hiding" in plain sight. Paintings and drawings can be built up from simple shapes, and drawings could even be made where one line is the edge of two figures. (Drawings by M. C. Escher, 1960, would be a good stimulus for this project.) There is a vast range of activities that are possible. The important thing is to guide a child's interactions with particular environments to enable him to attend to a pattern that was previously undifferentiated. As he becomes aware of the ways in which patterns are organized, he can become a competent perceiver.

OBJECT OR SHAPE PERCEPTION

Whenever a concrete object or an abstract shape is viewed as the figure or principal subject of attention, certain processes enable a person to distinguish features that are similar to and different from other objects. As perception of various invariant relationships among parts develops, the range of perceivable patterns also expands. Therefore, object or shape perception is defined as the ability to differentiate certain invariant relations in a figure and integrate them into a pattern. It also includes the ability to generalize an already known pattern to new figures that exhibit the same or similar relationships. Certain critical relations will include arrangement of lines, curves and angles, orientation in space, reversals and perspective transformations resulting in change of lengths of some parts. The generalization aspect of perceptual competence is particularly important in shape perception since it is not enough to be able to attend to the figure. Recognition depends on an ability to perceive previously learned invariant relationships. For example, learning to recognize the letter "A" means the detection of certain unchanging or invariant relationships in the way lines are put together (se Fig. 11). Note that it is certain higher-order relations that are unchanging and not the actual arrangement of the lines themselves.

In a natural environment the shapes perceived visually are always associated with some three-dimensional object. Thus it is very rare that the shape of a concrete object would be seen apart from the object itself.

The shape of "dogness" would be seen only in a dog and many cues other than shape will tell a person that a dog is approaching. Certain researchers (e.g., Piaget, 1967) have pointed out that changes in topological shape can be significant to a child and will be distinguished quite early. Topological changes include transformations an object may undergo without becoming a different object; for example, a mouth will be seen as a mouth when it is open, closed, smiling or frowning. Topological interpretations also help a child to know the meaning of certain types of shapes or answer questions about them, e.g., is an object likely to be soft or hard; is a mouth happy or unhappy?

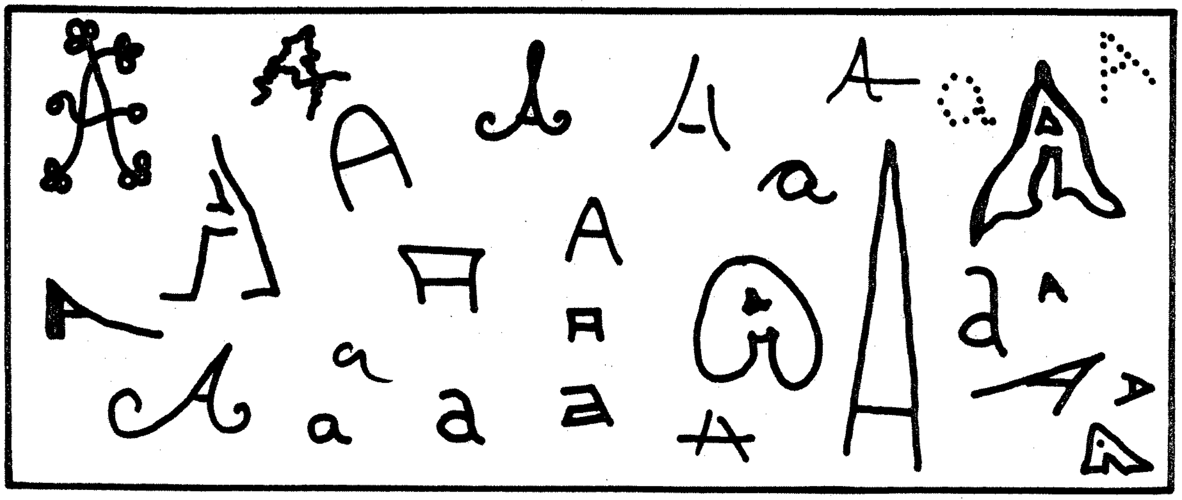

Figure 11.

A few of the many possible arrangements of lines that can be perceived as the letter A.

As a child begins to use two-dimensional representations and shapes such as picture books or letters and numbers, certain other kinds of discrimination become important. The orientation must be observed to know if a shape is right-side-up or up-side-down. Also, mirror image reversals and slight differences in lengths or sizes can make a big difference in meaning. Problems arise as abstract shapes are encountered because the child must attend to the strictly visual properties. There are no cues to "squareness" or "A-ness" other than the visually perceived relations themselves.

Many experiments have been conducted to determine the types of cues that are important and the ways in which shape learning through visual perception develops. As mentioned before, infants prefer patterns of moderate complexity and are able to detect the shape of an object despite changes in distance or in slant (Fantz, 1961; Bower, 1974). Apparently the newborn child is indifferent to face-like patterns but by two months, faces begin to be recognized and face-like patterns elicit smiling. (For summary of the wealth of research on face recognition see E. Gibson, 1969.)

Experiments on the development of abstract shape learning are of direct interest to teachers. James and Eleanor Gibson (Gibson, Gibson, Pick & Osser, 1962) conducted an extensive study on the discrimination of letter-like forms. Their prediction was that changes that were most directly affected by a child's experience would most easily be detected as different. For younger children it was, in fact, found that topological changes (a line to a curve or a curve to a line) were most easily differentiated. With the beginning of reading skill, rotation and reversal changes were differentiated, although mirror-image reversals were the most difficult differentiations to make. The alterations that were most difficult to differentiate were slightly foreshortened images that corresponded to a change of slant. Gibson hypothesized that since letters had to be recognized even when slanted, the projectional differences had to be continually ignored. Only the oldest group of children tended to notice these projected differences.

There is a great wealth of other research available and many of the findings have yet to be interpreted. However, some educational implications can be drawn from what is known. First of all, three-dimensional objects seem to be more interesting and more easily distinguished by young children. Whenever possible, actual objects should be used so that children can manipulate them and use them, verifying their visual experience through other sensory modes. Whenever pictures are used, they should be clear and unambiguous unless the experience is being planned to develop recognition and generalization abilities. As work with abstract shapes and forms begins, teachers can be particularly helpful in pointing out critical features. For example, lines are different from curves; a sharp corner is an angle and is different from a rounded edge; a triangle means three angles, etc. By calling attention to the important parts of a shape, teachers can help a child know what to look for when trying to recognize a new shape. As reversals and rotations become important (for example, the difficult set of letters, b, p, q, d), a teacher can offer many experiences in verticality and laterality to help call attention to the differences that orientation makes. Whatever the task is, a teacher should endeavour to help a child determine what the invariable relationships are in the object at hand.

Many perceptual training programs have been developed over the last few years, especially techniques to help children learn letters and numbers. Current research indicates that no one approach thus far developed is significantly the best. Some approaches work well for one child but not for another. Yet overall, they appear to be equally effective, as long as they help a child differentiate the critical features of the shape. For this reason, no one set of exercises can be dictated for all children. The teacher must be aware of developmental sequences and be able to diagnose a child's needs at any one time. Experiences can then be devised to help meet those needs.

A wealth of learning experiences is possible, even using just every day materials. Classification experiences (and experiences for many other cognitive processes) can deal with objects, forms, flat patterns or letter shapes. Drawings can be made with only lines or curves. Clay can be sculpted into letter forms and then sketched. Designs can be made with all "p's" or all "b's" or symmetry can be discussed along with differences between a "d" and a "b". With a small hand mirror children can find ways to divide objects in the room so that a simple symmetrical pattern is made with the reflection in the mirror. A simple shape can be cut out of paper and used as a stencil upside-down and backwards to show all possible orientations. Science lessons can focus on patterns in shells, trees or flowers and children can discover which patterns can be viewed in only one orientation and which could be rotated or reversed but still remain the same. Shape even enters into movement and can be incorporated as part of any psychomotor activity, for example, running in curves or running in straight lines. Obviously, almost any activity in which objects or shapes are involved will offer an opportunity to help children become aware of the ways in which objects and shapes can differ. This awareness will help them become more competent in knowing how to look and what to look for when a new pattern is encountered.

SPACE, DISTANCE OR DEPTH PERCEPTION

In any three-dimensional visual array there are certain cues which indicate the presence of depth or distance. Many of these cues can also be represented on a two-dimensional plane. Visual space perception refers to the process whereby one is able to accurately differentiate nearness in space from farness in space and apprehend the relationships between them by integrating them into patterns which define depth. It also includes being able to recognize pictorial (two-dimensional) cues that represent those relationships.

In viewing any ordinary three-dimensional objects there are certain cues that will invariably indicate the presence of depth. Binocular vision can indicate depth through the degree of convergence (the extent to which the eyes must turn towards each other) and through retinal disparity (simultaneous comparison of two angles of view). *Depth information will also be available through motion parallax since a three-dimensional object will appear slightly different when viewed from two different head positions (see Fig. 8, p. 15). the old time stereoscope tried to stimulate retinal disparity by having each eye see a picture taken from slightly different angles.

In regular, two-dimensional representations, it is not possible to get depth information through binocular vision or motion parallax. Therefore, painters and students of vision have discovered many pictorial cues that can be isolated and used to represent depth on a flat surface. With the advent of color photography, virtually all depth cues can be represented except for those depending on the comparison of two angles of view. Some of the most important pictorial cues include:

1. Shading. Because of differential facing, some portions of objects will reflect more light than others.

2. Linear perspective. Parallel lines converge as the distance from the viewer increases.

3. Proximal size. An object will appear to grow smaller as it recedes from the viewer.

4. Interposition. If one object obscures part of another object, it appears be be in front of that object.

5. Texture gradient. A texture will appear to be coarser when it is seen close at hand.

6. Color intensity. Because of the scattering effect of the atmosphere on light, closer objects will appear to be brighter and more intensely colored; more distant objects will appear less intensely colored and more "bluish".

These various cues are continually present in a three-dimensional environment. But in a two-dimensional representation such as a line drawing, one or two of the cues can be sufficient to indicate depth. In fact, minimal artists of the last few years have taken great delight in seeing how few contrasts are necessary to give a visual impression of space.

In seeking to determine which cues are preceivable by the human infant, many researchers have investigated the infant's detection of depth. In an ingenious series of experiments conducted by T. G. R. Bower (1974) it was demonstrated that an infant was able to differentiate between a sphere and a flat disc of the same size. However an infant could not differentiate between two-dimensional, projected images of the same objects.

Since this was found also to be true for infants viewing with one eye only, Bower concluded that motion parallax, as well as binocular vision, gives depth information to an infant. The infant apparently did not notice the purely pictorial cues. A wide range of experiments on a visual cliff (see E. Gibson, 1969) indicates that as early as seven months cunildren avoid crawling into areas that appear to have a cliff (a sudden drop or cavity in the floor). But the refinement of depth perception continues well into maturity. Older children become increasingly accurate in visual estimates of distance, and near and far objects can be matched more accurately in terms of size. As a child gains experience, he is able to take into consideration changes of appearance that will occur with a change in viewing position and he is able to duplicate in drawings a greater range of depth cues. The training of the eye to observe depth cues and the hand to reproduce them can continue throughout life, and painters in the classical tradition often devoted their lives to mastery of that art.

Accurate and efficient depth vision is required by many human activities. Hitting a fast ball and catching a fly are two spectacular examples. The precise depth of a surgeon's incision could make a difference between life and death. Threading a needle, hammering a nail, and harpooning a whale all depend on very finely coordinated depth judgements. Any specialized profession, like architectural drawing or representational painting, depends on a very great ability to make use of cues that indicate depth.

Drawing is perhaps one of the best experiences to help a child become aware of the ways objects are arranged in space. A simple task might be to light a sphere from one side only and ask children to draw it. They can then discuss how it differs from a flat circle. Other more complicated three-dimensional objects can be drawn and eventually perspective can be intorduced. One complicated task that Piaget describes is to have children look at an arrangement of objects from one side and then draw what the arrangement would look like from the other side, a powerful act of inference which depends on perception as well as cognition.

But drawing is not the only way children can learn about depth. Almost every activity, such as sewing, block-building, or sports develops depth vision. Constructing three-dimensional block structures and copying three-dimensional shapes with blocks depends on depth perception, as does estimating and then measuring sizes of fence posts, boundary lines, buildings and fellow students. Children can measure shadows of objects at different times of the day to understand angles of projection and they can measure distant objects by comparing them to known distances or lengths. Development in the areas of art, math and science depend on a child's increasing awareness of distance and depth and on his understanding of the perceptual factors that are involved in dealing with size and distance.

MOTION OR EVENT PERCEPTION

Whenever movement occurs in a visual field, there is a change in the existing spatial pattern. Also, any change always occurs over a certain period of time. In order to interpret continuous changes in the visual field as a unified motion or event the viewer must detect certain visual relations that remain constant over time. Therefore, perception of events is defined as the ability to differentiate, integrate and generalize relations that remain invariant despite continuous transformations over time.

The perception of movement implies that in a stimulus that is changing with respect to the background, some invariant aspect of the stimulus is perceived. Usually the invariance is that the stimulus object remains the same, even though it is moving. If that invariance were not perceived the changes would be interpreted as separate occurances and not as a unified event. Investigations of such diverse phenomena as causality, conservation, object constancy, motion and apparent motion have suggested that all these perceptions have one thing in common. In order for the occurance to be perceived, the viewer must be able to detect some relationship that remains constant. In the case of Piagetian conservation exercises, the quantity of water or clay must be perceived as constant. In object permanence, it is the object itself that must be perceived as unchanging even if it is hidden from view by other another object. For causality to be perceived, the impetus of motion must be seen to continually exist and to pass from one object to another. Karl Lashley (1951) pointed out that the perception of sequential structure is as yet one of the least understood phenomena in psychology, but it seems that some invariant property of a sequence must be detected if that sequence is to be seen as a singular event.

Many experiments have been done on children's perception of speed and motion as well as on events like shadows that enlarge suddenly in the visual field (looming). Work has also been done to trace the development of pursuit movements of the eyes in infants that are watching objects move. Apparently, even very young infants can detect movement in the visual field. Eye movements become more coordinated and by two months of age infants are generally able to follow an object in simple motion. Sudden magnification is also perceived by an infant two months old who will blink with the sudden approach of an object (White, 1968). As the child matures, his judgements of speed and relative speed become more accurate. He also becomes aware of the relations between distance and time and is able to project the path of an object that has been tossed into the air. But, in spite of these observations, relatively little is actually known about the ways in which motion and event perception develop.

Children will do many things in school that require competent judgements of motion and speed. These judgements will also be closely related to judgements of depth and distance, since projecting the trajectory of a fly ball and arriving in time to catch it involves both time and distance estimations. Science and math experiences provide excellent opportunities to study aspects of movement and to improve in the ability to study aspects of movement and to improve in the ability to observe and predict motion. For example, children can see what happens when one object strikes another, what difference relative weight makes and how distance is involved. They can compare falling items for different objects and for varying heights.

Interesting experiences in movement perception can also be built around dance activities since dance depends solely upon the movement itself for its enjoyment. Children can create shapes through movement or remember and repeat another child's pattern. They can also begin to appreciate the qualities of fast or slow and jerky or smooth. These are obviously only a few of the experiences that can contribute to the development of movement perception but they indicate the range and depth of learning that can occur. Competent motion perception will include the ability to confidently predict and relate to changes of space over time. It will also include the ability to be aware of and take joy in the aesthetic aspects of movement patterns.

PROTOTYPICAL LEARNING EXPERIENCES IN VISUAL PERCEPTION: INTEGRATING SCIENCE AND GRAPHIC ARTS

<u>Prototypical Experience I:</u> <u>Object Patterns</u>

<u>Process:</u> Visual shape perception.

<u>Process Objective:</u> To be able to perceive accurately the distinctive shapes or patterns of objects.

<u>Related Processes:</u> Classification, Observation, Recording, Graphic Construction.

<u>Content:</u> Science (Biology), Art (Two-dimensional Design).

<u>Content Objectives:</u>

1. To know that natural objects have a shape or pattern.

2. To know that the pattern of one type of object (e.g., oranges) will have a pattern that is different from another type (e.g., apples).

3. To know that the shape of an object can be recorded in a diagram by careful observation and accurate drawing.

4. To know that the word pattern or shape refers to an arrangement of lines and not only to a specific drawing or a specific color.

5. To know that a pattern can be made larger and used as the basis of a design.

6. To know that when an art project is being planned, the visual unity of the entire page must be taken into account.

Experience:

Various natural objects were displayed at stations. Children were asked to carefully observe the objects and draw them as accurately as possible with pencil. They were then asked to choose the pattern of one of their pencil drawings and use that as the basis for a larger art project.

I. Arrangement of Environment

Space and furniture. Objects were arranged in groups at four (or five) tables with ample space between them for children to observe and draw. Painting areas were arranged so that when the pencil drawings were complete, painting could begin.

Age and materials. First grade. Oranges and apples cut in half both horizontally and vertically through the center; thin ring cut from a pepper and thin slice of cucumber; some simple shells; microscope slide of an onion skin.

Crayons were used for the graphic design.

Second grade. Same objects except that more complicated shells (spirals and ovals) were used and more complicated sections of peppers which included seeds.

Paint was used and children were urged to balance the design with respect to a large piece of paper.

Ordering of materials. Objects were grouped into separate stations, and arranged on mats on an empty table so that they were visually clear and distinct (figure-ground).

II. Guided Interaction

Explanation. Observation was discussed as a process and the importance of careful observation and drawing was stressed. When preparing to paint, it was emphasized that the shape or pattern could be any color when used for a design and that the arrangement of lines in the pattern was the most important part of this design.

Observation. Children were encouraged to look carefully and when possible to label the designs clearly. When children were rushing or scribbling, they were asked to take more time and draw as accurately as possible. In the painting (or coloring) time children were urged to make the design large, make the pattern clear and use the whole page.

Prototypical Experience II: Light and Shadows. (Done with kindergarten and third grade.)

Process: Visual Space Perception.

Process Objective: To be able to perceive shadows in relation to objects and the depth cues that shadows can create.

Related Processes: Observation, Prediction, Experimentations, Inference, Graphic construction, Two-dimensional representation of depth.

Content: Science (Physics), Art (Graphic Design).

Content Objectives:

1. To know that light travels in a straight line.

2. To know that if an object blocks the path of light a shadow is formed.

3. To know that a sphere will be shadowed on one side where light does not fall directly (whereas a flat disc will not have shadows).

4. To know that a sphere can be represented on paper by use of a dark color to indicate shading.

Experience:

An experiment with pieces of cardboard with holes in them deomnstrated that for light to pass through all the holes they must be arranged in a straight line. An arrangement with mirrors showed that even reflected, light travels in straight lines. Objects were then placed on an overhead projector to determine the relation between shape of an object and shape of its shadow.

With kindergarten, the experience moved to relating shape of their own body to their shadow on the wall. Shadow designs were then made by creating a shadow arrangement on a piece of paper and coloring the shapes.

Third graders were able to appreciate more subtle relationships of space and shadows. After discussing differences between round and flat they were asked to observe a sphere lighted on one side only and to draw the sphere by using appropriate shading.

I. Arrangement of Environment

Space. All windows and doors were darkened so that the light source could be controlled.

Age and materials. Kindergarten. Strong flashlight and mirrors supported by small balls of clay; overhead projector, objects, and plain wall; white paper for design surrounded by dark poster board so that picture area stood out clearly.

Third grade. Candle and cards with tiny holes in center; flashlight and mirrors. For depth drawings, yellow spheres were supported by a long piece of wire and lighted from one side. Yellow crayons were used for spheres; black crayons for the shading.

II: Guided Interaction

Explanation and demonstration. The experience followed the description above fairly straight-forwardly. Emphasis was placed on observing and on trying to reason out (predict) what would occur. The connection between straight lines of light and shadows was stressed and the relation of shape to shadow. For the depth drawings, accurate observation was stressed, pointing out that the drawing will change depending on the position of the viewer.

Prototypical Experience III: Colors and Saturation (Done with second and third grade.)

Process: Visual color preception.

Process Objective: To be able to perceive differences in shade (saturation) of a color.

Related Processes: Observation, Prediction, Experimentation, Graphic Construction.

Content: Science (Chemistry), Art (Two-dimensional design).

Content Objectives:

1. To know that a light-colored solution can be made darker by adding more color.

2. To know that lightness and darkness can be represented with crayons by controlling the pressure of application.

3. To know that a visual design is created by contrast. When only one color is used, the contrast must be of lightness and darkness.

4. To know that some fluids will not mix with each other (e.g., oil and water).

5. To know that two colors in the same solution can mix to form a different color (e.g., blue and yellow to make green).

Experience:

Color mixing was demonstrated on an overhead projector as well as the non-mixing of water with oil. After discussions of saturation and ways to represent darkness with crayon pressure, children were asked to make a design using only three shades of one color.

I: Arrangement of Environment

Space. Room was darkened for part of experience using overhead projector.

Materials. Overhead projector and clear dish of water; food coloring; clear vegetable oil; crayons and paper.

II: Guiding Interaction

Explanation and demonstration. Children were asked to predict what would happen if food coloring was dropped into water. Would it stay in one place, spread quickly or spread slowly. (It spreads slowly in lines; swirls.) Children were then asked what would happen if more color was added. (It gets darker.) Oil was used and colored water was dropped in. (It remained as droplets and did not mix.) Also two colors were mixed to get a third.

Children then described how different darknesses could be represented with crayons and prepared a sample sheet of dark, medium and light shades. When the sample was completed, they were asked to make a design using all three shades clearly.

Observation. In preparing the sample sheets, children were asked to have three clear shades and to try again until the three shades were distinct.

Doing the monochromatic designs was difficult for many children. By asking them to point out where the three shades were they were helped to make the contrast clear. Filling the whole page and making the dark areas as dark as possible helped increase the visual clarity and highlighted the notion of monochromatic design.

REFERENCES

Bower, T. G. R. The visual world of infants. Scientific American, December, 1966.

Bower, T. G. R. Slant perception and shape constancy in infants. Science, 1966b, 151, 832-34.

Bower, T. G. R. Development in infancy. San Francisco: W. H. Freeman & Co., 1974.

Cassirer, E. The philosophy of symbolic forms, (Vol. 2). New Haven: Yale University Press, 1953.

Conway, P. W. Perceptual competence and the ANISA process curriculum. World Order, Winter, 1973-74, pp. 23-35.

Escher, M. C. The graphic work of M. C. Escher. New York: Duell, Sloan & Pearce, 1960.

Evans, R. M. The perception of color. New York: Wiley and Sons, 1974.

Fantz, R. L. The origin of form perception. Scientific American, 1961, 204, 66-72.

Fantz, R. L. Pattern vision in newborn infants. Science, 1963, 140, 296-97.

Forgus, R. H. The effect of different kinds of form pre-exposure on form discrimination learning. Journal Comparative Physiology and Psychology, 1958, 51, 75-8.

Frisch, K. von. The dance language and orientation of bees. Cambridge, Mass.: Harvard University Press, 1967.

Gibson, E. J. Principles of perceptual learning and development. New York: Meredith Publishing Co., 1969.

Gibson, E. J., Gibson, J. J., Pick, A. D. and Osser, H. A. A developmental study of the discrimination of letter-like forms. Journal Comparative Physiology and Psychology, 1962, 55, 897-906.

Gibson, E. J. and Walk, R. D. Effect of prolonged exposure to visually presented patterns on learning to discriminate them. Journal Comparative Physiology and Psychology, 1956, 49, 239-42.

Gibson, J. J. The senses considered as perceptual systems. Boston: Houghten Mifflin Co., 1966.

Greenberg, D., Uzgiris, I. and Hunt, J. McV. Hastening the development of the blink response with looking. Journal of Genetetic Psychology, 1968, 113, 167-76.

Hochberg, J. E. Perception. Englewood Cliffs, NJ: Prentice-Halls, Inc., 1964.

Hubel, D. E. The visual cortex of the brain. Scientific American, November, 1963, 132-40.

James, W. The principles of psychology. New York: Henry Holt and Co., 1980.

Kessen, W., Haith, M. M. and Salapatek, P. H. Human infancy: A bibliography and guide. In Paul H. Mussen (Ed.), Carmichael's handbook of child psychology. New York: John Wiley & Sons, 1970.

Lashley, K. S. The problem of serial order in behavior. In L. A. Jeffress (Ed.), Cerebral mechanisms in behavior. New York: Wiley & Sons, 1951, 112-36.

Neisser, U. Cognitive psychology. New York: Meredith Publishing Co., 1967.

Piaget, J. The mechanisms of perception. London: Routledge & Kegan Paul, 1969.

Piaget, J. and Inhelder, B. The child's conception of space. London: Routledge & Kegan Paul, 1967.

Pick, H. L. Jr. and Pick, A. D. Sensory and perceptual development. In Paul H. Mussen (Ed.), Carmichael's handbook of child psychology. New York: John Wiley & Sons, 1970.

Pritchard, R. M. Stabilized images on the retina. Scientific American, June, 1961, 117-23.

Rockstein, M. The physiology of insecta, (Vol. II). New York: Academic Press, 1974.

Walk, R. D. and Gibson, E. J. A comparative and analytic study of depth perception. Psychological Monographs, 1961, 75, (15, whole no. 519).

Walk, R. D., Trychin, S. J. and Karmel, B. Z. Depth perception in dark-reared rats as a function of time in the dark. Psychon. Science, 1965, 3, 9-10.

Walls, G. L. The vertebrate eye and its adaptive radiation. Cranbrook Institute of Science, 1942.

White, B.L. An experimental approach to the effects of experience on early human behavior. In J. Hill (Ed.), Minnesota symposium on child psychology, Minneapolis: University of Minnesota Press, 1, 1968.